# Retrieving the Height of Smoke and Dust Aerosols by Synergistic Use of Multiple Satellite Sensors

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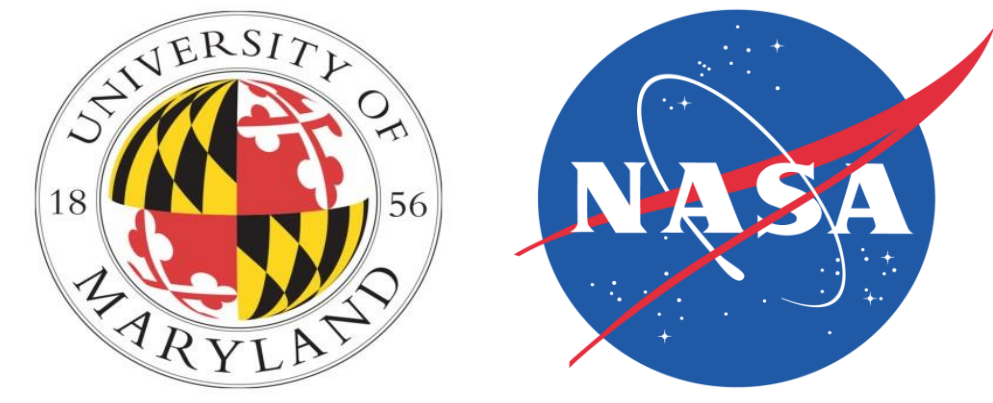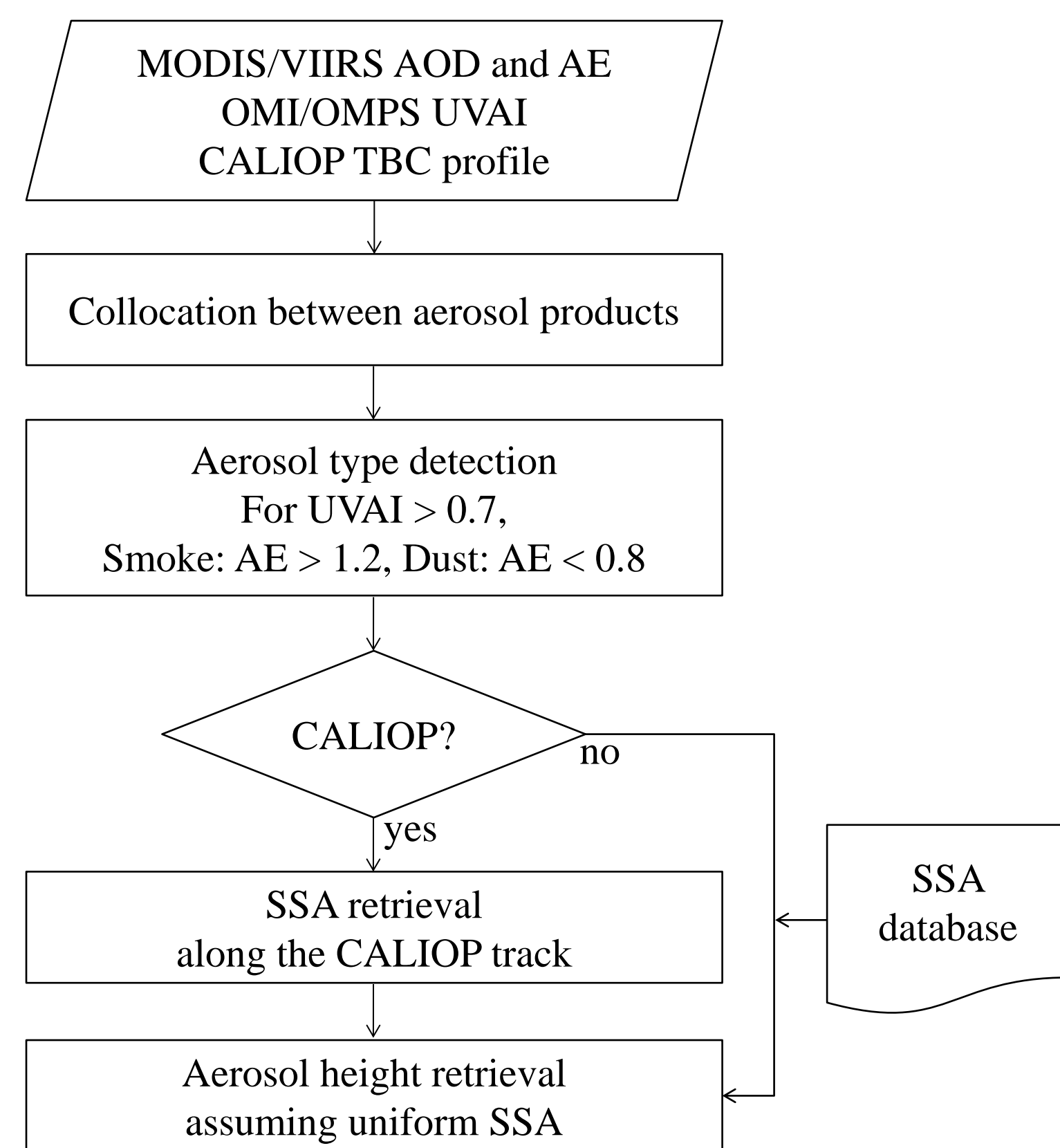
ASHE Algorithm

The Aerosol Single scattering albedo and Height Estimation (ASHE) algorithm was first introduced in Jeong and Hsu (2008) to provide aerosol layer height and single scattering albedo (SSA) for biomass burning smoke aerosols. By using multiple satellite sensors synergistically, ASHE can provide the height information over much broader areas than lidar observations alone. The complete ASHE algorithm uses aerosol data from MODIS or VIIRS, OMI or OMPS, and CALIOP. A simplified algorithm also exists that does not require CALIOP data as long as the SSA of the aerosol layer is provided by another source. Several updates have recently been made: inclusion of dust layers in the retrieval process, better determination of the input aerosol layer height from CALIOP, improvement in aerosol optical depth (AOD) for nonspherical dust, development of quality assurance (QA) procedure, etc.
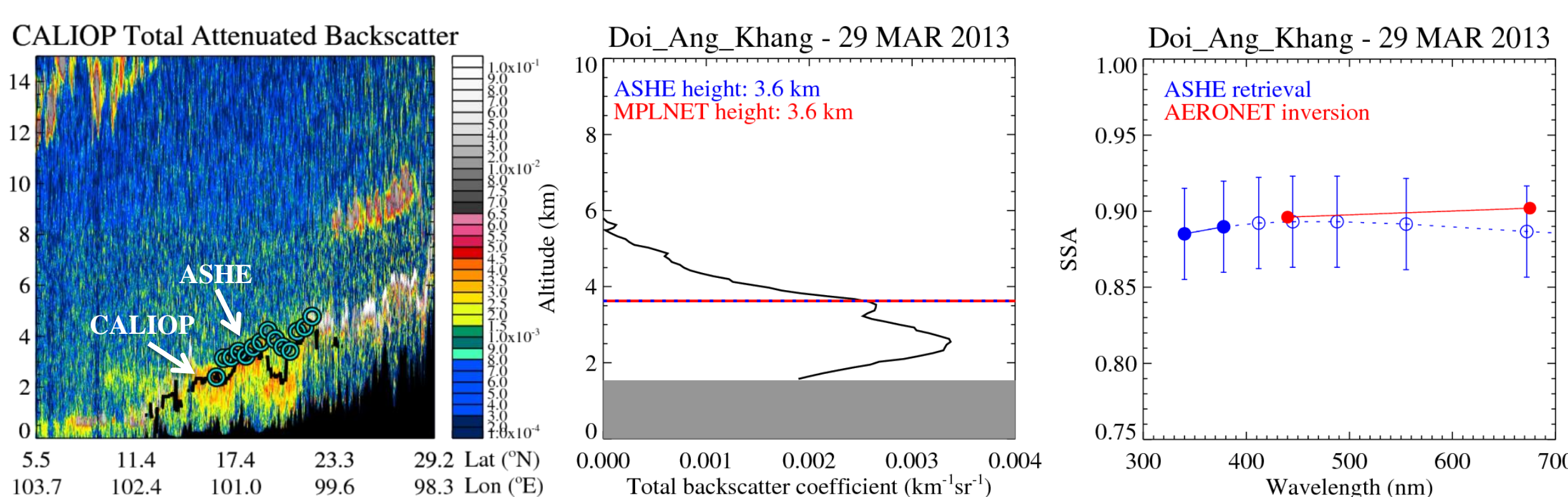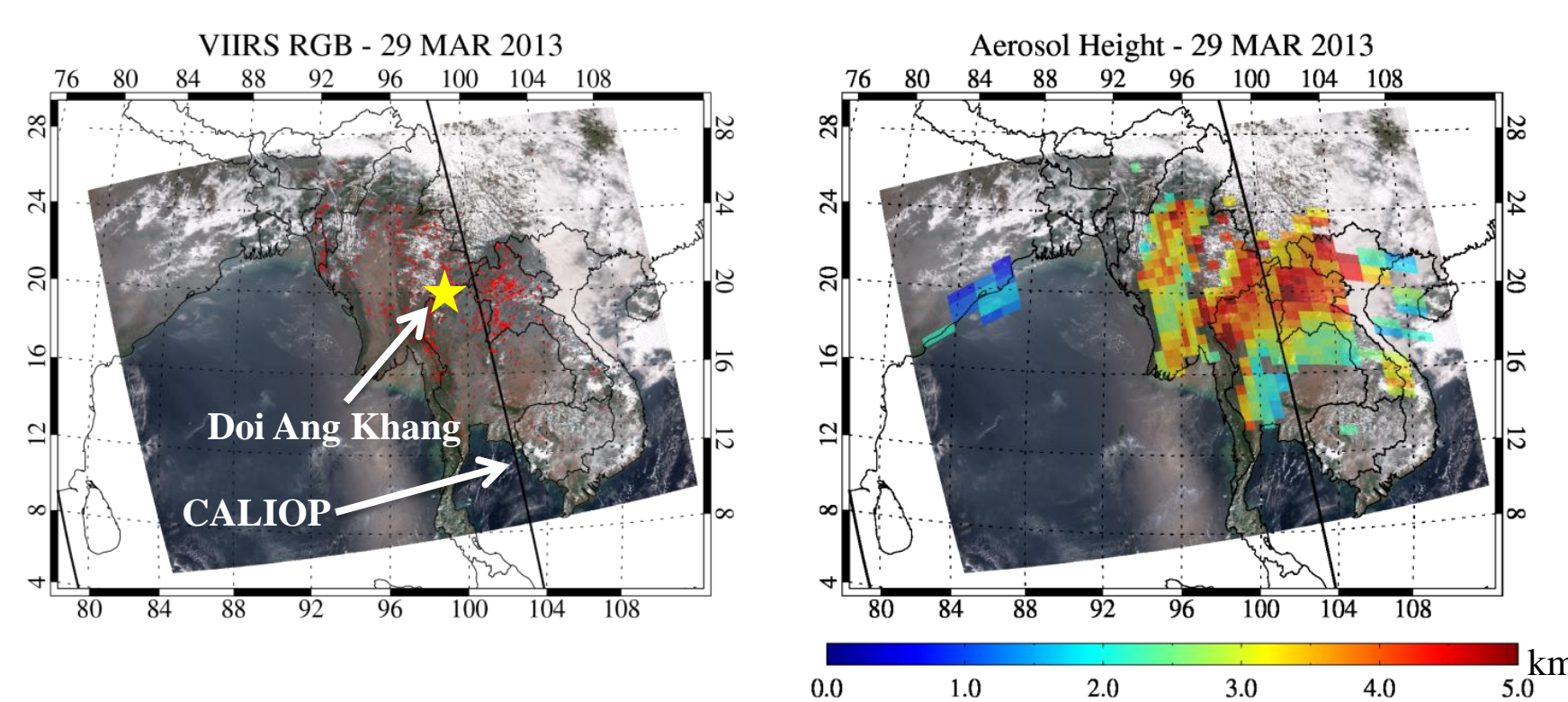
Method

The ASHE algorithm utilizes the sensitivity of UVAI to AOD, SSA, and aerosol height. The SSA or height can be retrieved if the other two parameters are constrained. Thus AOD and aerosol height should be constrained for retrieving SSA, and AOD and SSA should be constrained for aerosol height.

Flowchart of the ASHE algorithm.

Case study

Application of the ASHE algorithm to a biomass burning smoke event over Southeast Asia, and comparisons of aerosol height and SSA against CALIOP, MPLNET, and AERONET data.

Evaluation

The ASHE algorithm has been evaluated for wildfire smoke aerosols over North America, biomass burning smoke aerosols over Southeast Asia, and Saharan dust over the Atlantic Ocean. In particular, a thorough assessment was made for the smoke aerosols over Southeast Asia based on comprehensive ground-based observations, including MPLNET and AERONET during the 7-SEAS/BASELInE field campaign.
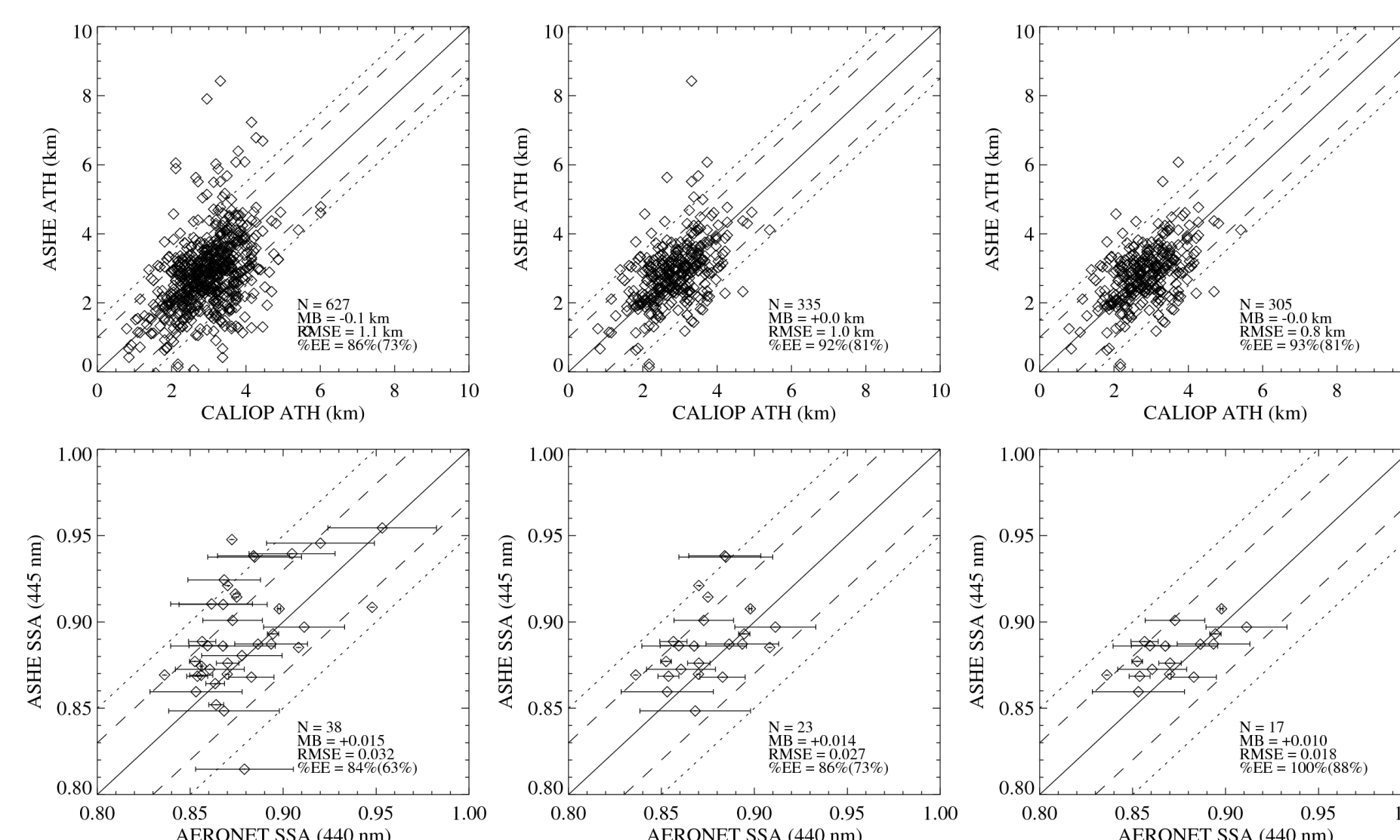
North American wildfire smoke
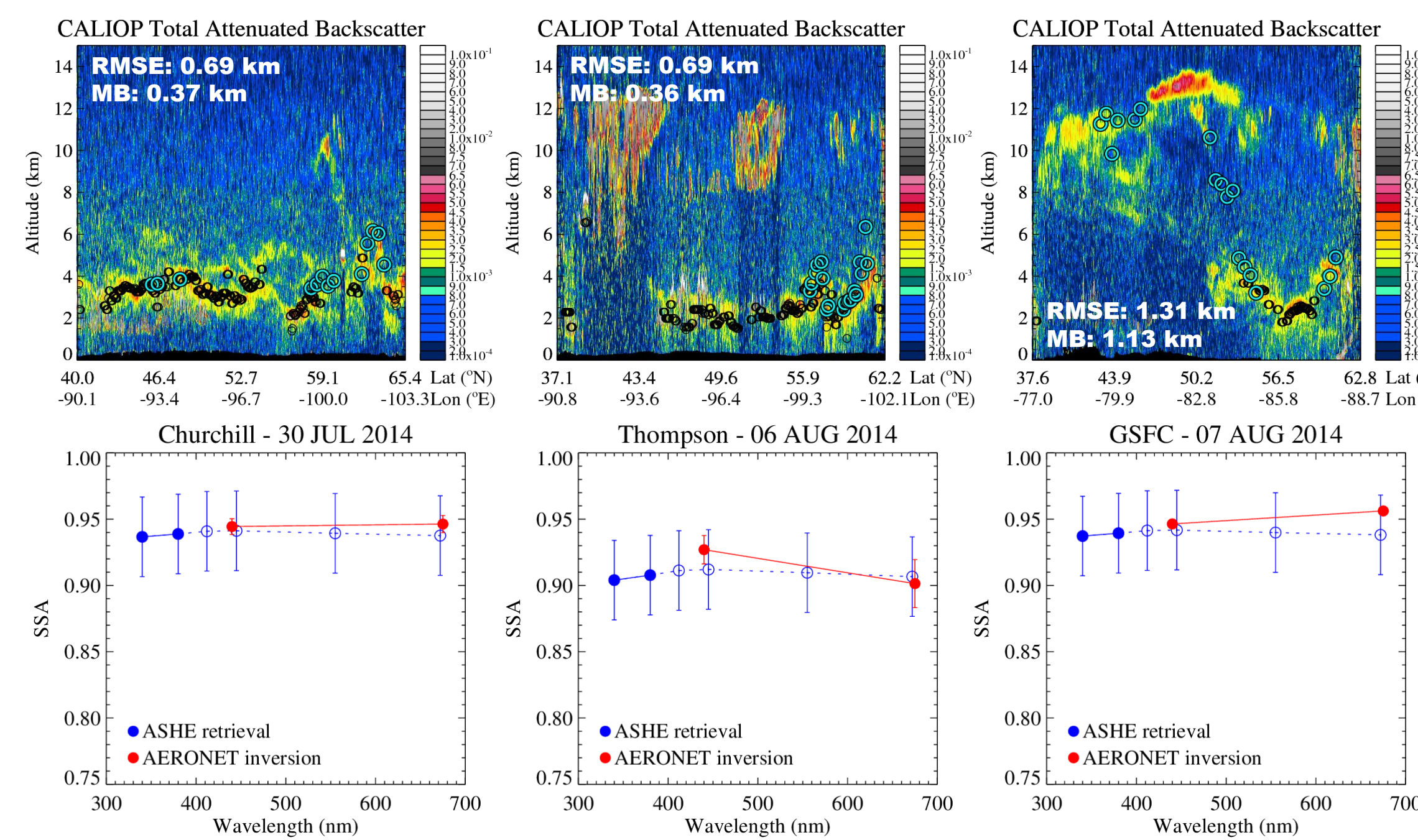
Comparisons between ASHE-retrieved and CALIOP-derived aerosol height (upper) and corresponding SSA comparisons between ASHE and AERONET (lower) for wildfire smoke cases over North America.

Saharan dust
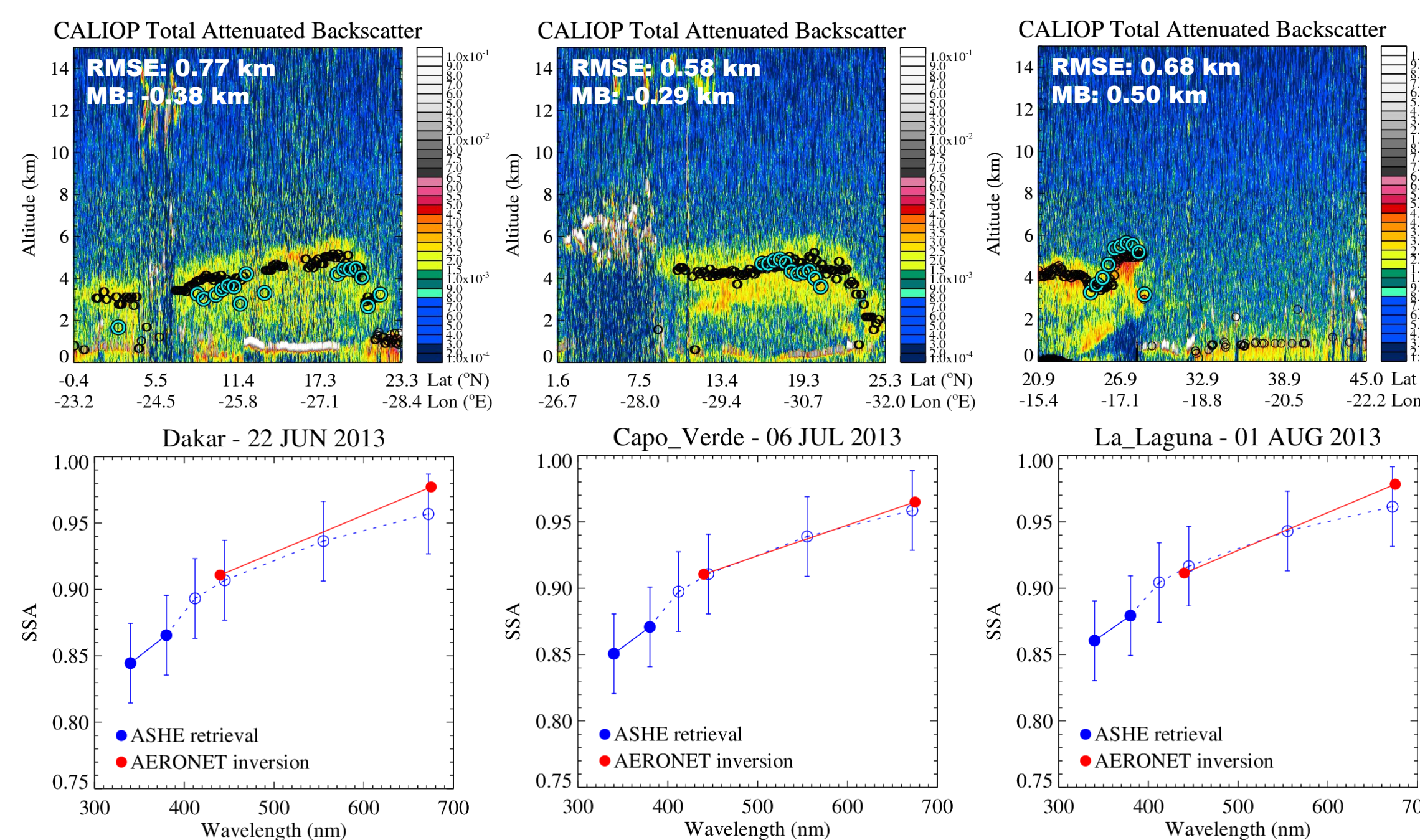
The same as above except for Saharan dust cases over the Atlantic Ocean.

Biomass burning smoke over Southeast Asia

Scatterplots between ASHE-retrieved and CALIOP-derived aerosol height (upper) and corresponding SSA comparisons between ASHE and AERONET (lower) for biomass burning smoke aerosols over Southeast Asia. Data for different QA flag criteria are shown, which increase from left to right.
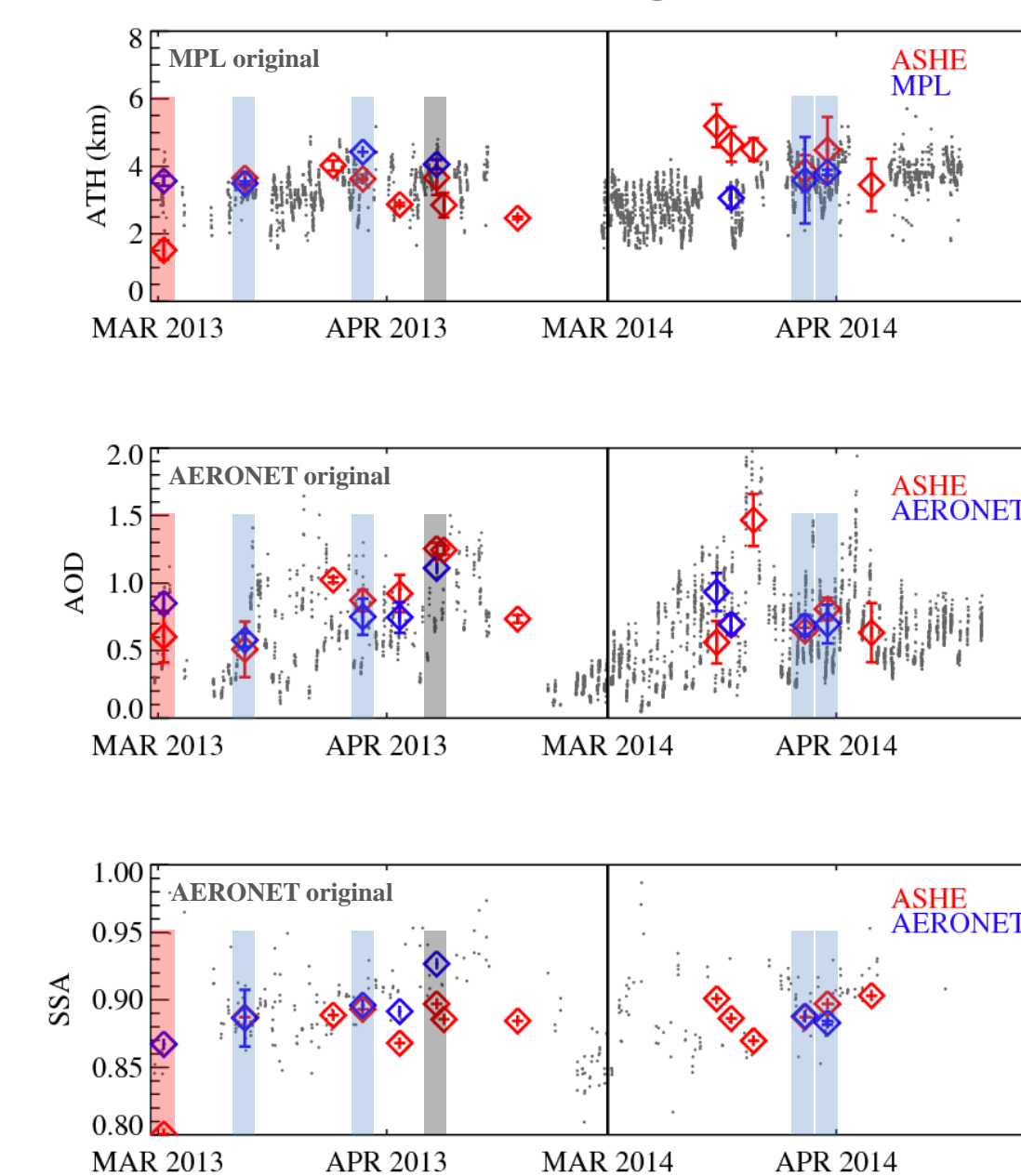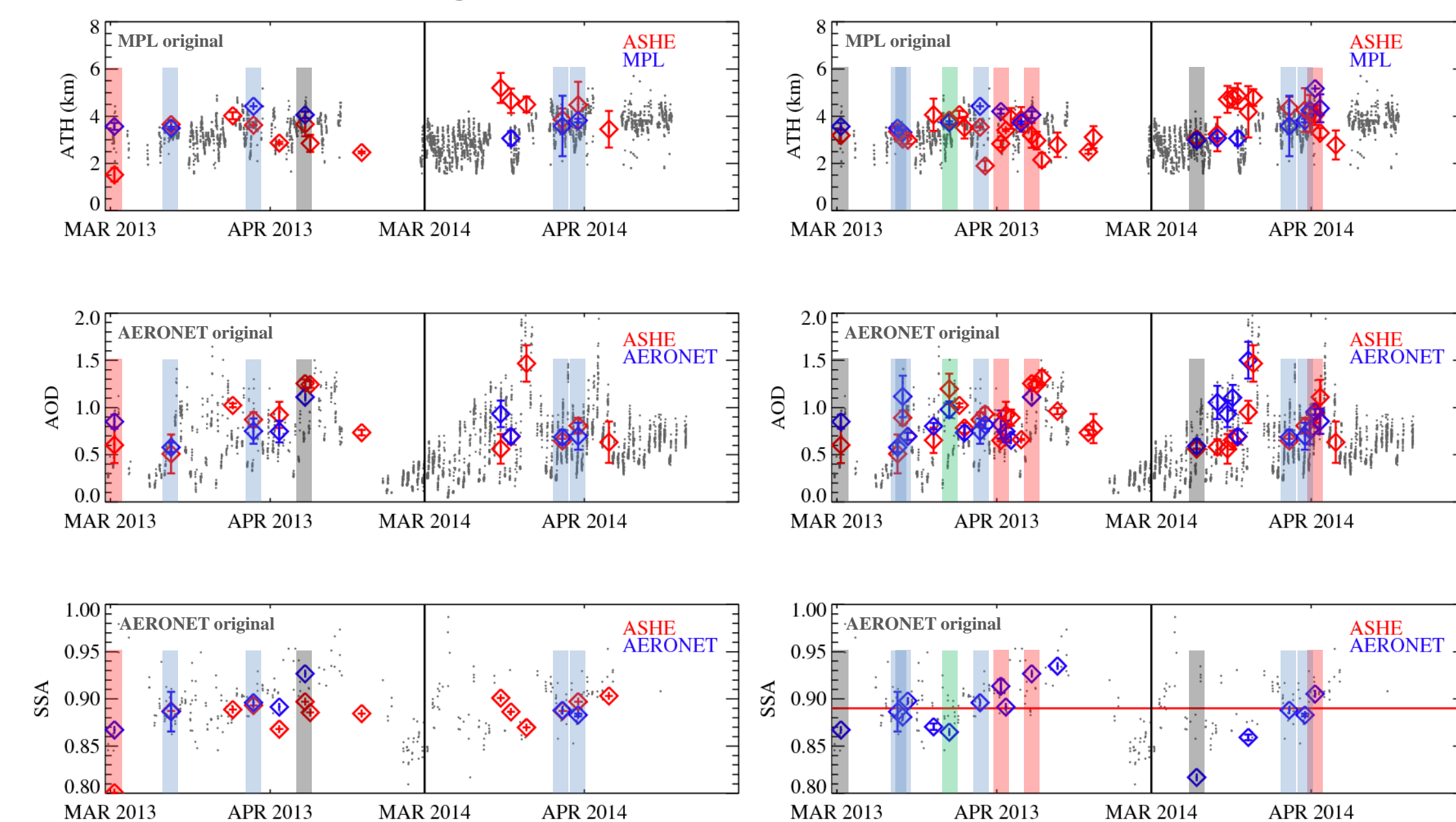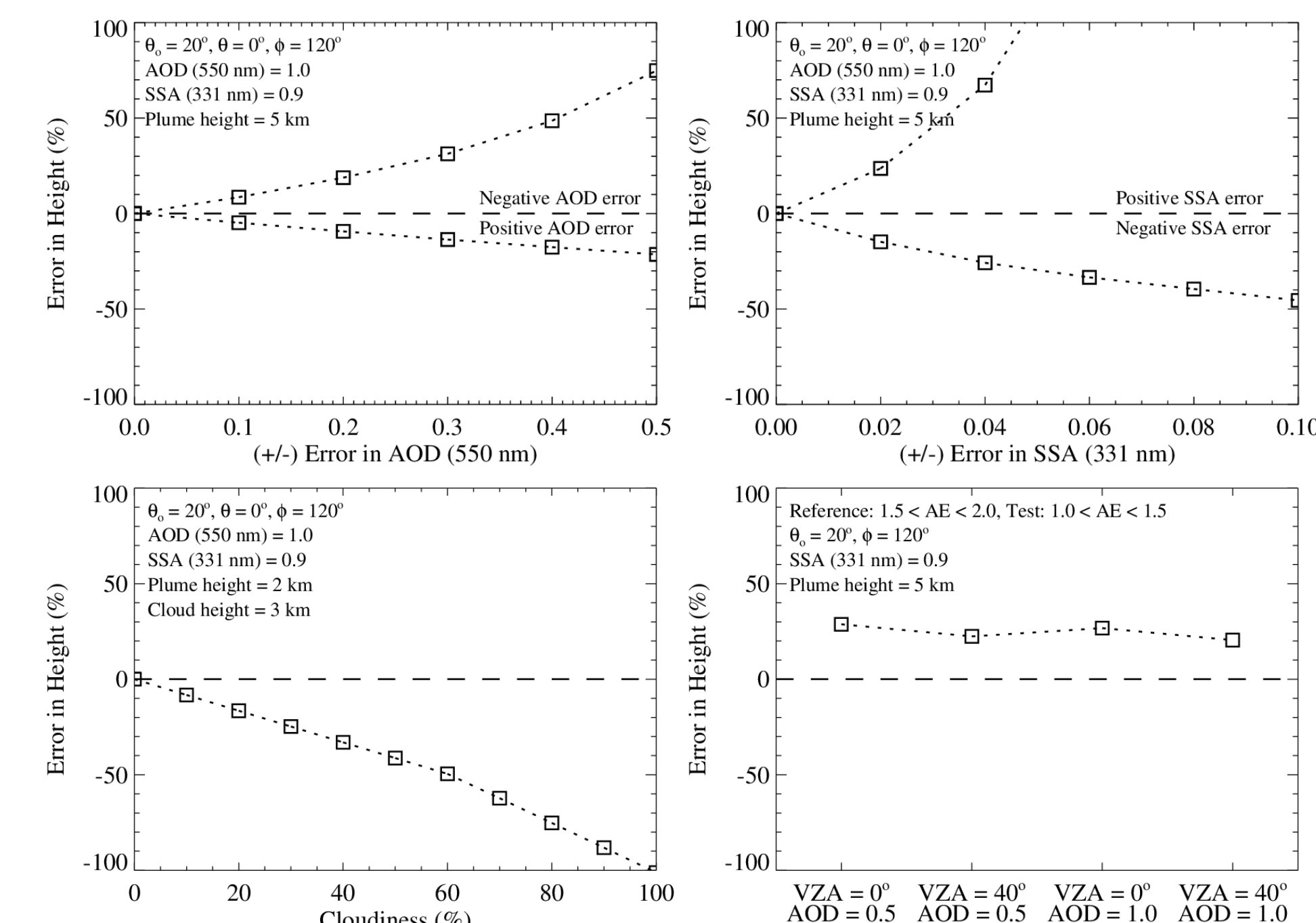

Error < 1 km: everything working correctly AOD and SSA errors cancel each other Not explained
Error > 1 km

Comparisons between ASHE-retrieved and MPLNET-derived aerosol height (upper) and corresponding AOD (middle) and SSA (lower) comparisons between ASHE and AERONET.

Uncertainty

Estimated uncertainties in the aerosol layer height retrievals as a function of AOD, SSA, cloud fraction, and AE. 20% error in AOD can attribute to 10-20% error in the aerosol layer height retrievals. SSA is the largest source of uncertainty and can be minimized when CALIOP aerosol layer height is available. Data with high cloud fraction can be filtered or flagged as lower quality. AE dependence is planned to be implemented in the future.

Conclusions

- Aerosol layer height can be retrieved over broad areas by synergistic use of MODIS/VIIRS, OMI/OMPS, and CALIOP observations.
- The algorithm is stronger for large-scale, single-layer aerosol events than small-scale, multilayer cases.
- The algorithm can be applied without CALIOP observations with a decrease in performance but an increase in spatiotemporal coverage.
- For the simple algorithm, a SSA climatology derived from the ASHE algorithm and/or AERONET can be used to constrain the SSA for different aerosol types over the globe.
- In addition, the ASHE-retrieved SSA can potentially be used in the Deep Blue algorithm to constrain aerosol model for better performance.
- Currently, only one smoke and one dust aerosol models are used; more sophisticated aerosol models are planned to be included for applications to other regions.

References

Jeong, M.-J., and N. C. Hsu (2008), Retrievals of aerosol single-scattering albedo and effective aerosol layer height for biomass-burning smoke: Synergy derived from "A-Train" sensors, *Geophys. Res. Lett.*, 35, L24801, doi:10.1029/2008GL036279.

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